📄 Wormhole Throat Collapse in Pawan Upadhyay's Pressure–Curvature (PPC) Law of Gravity

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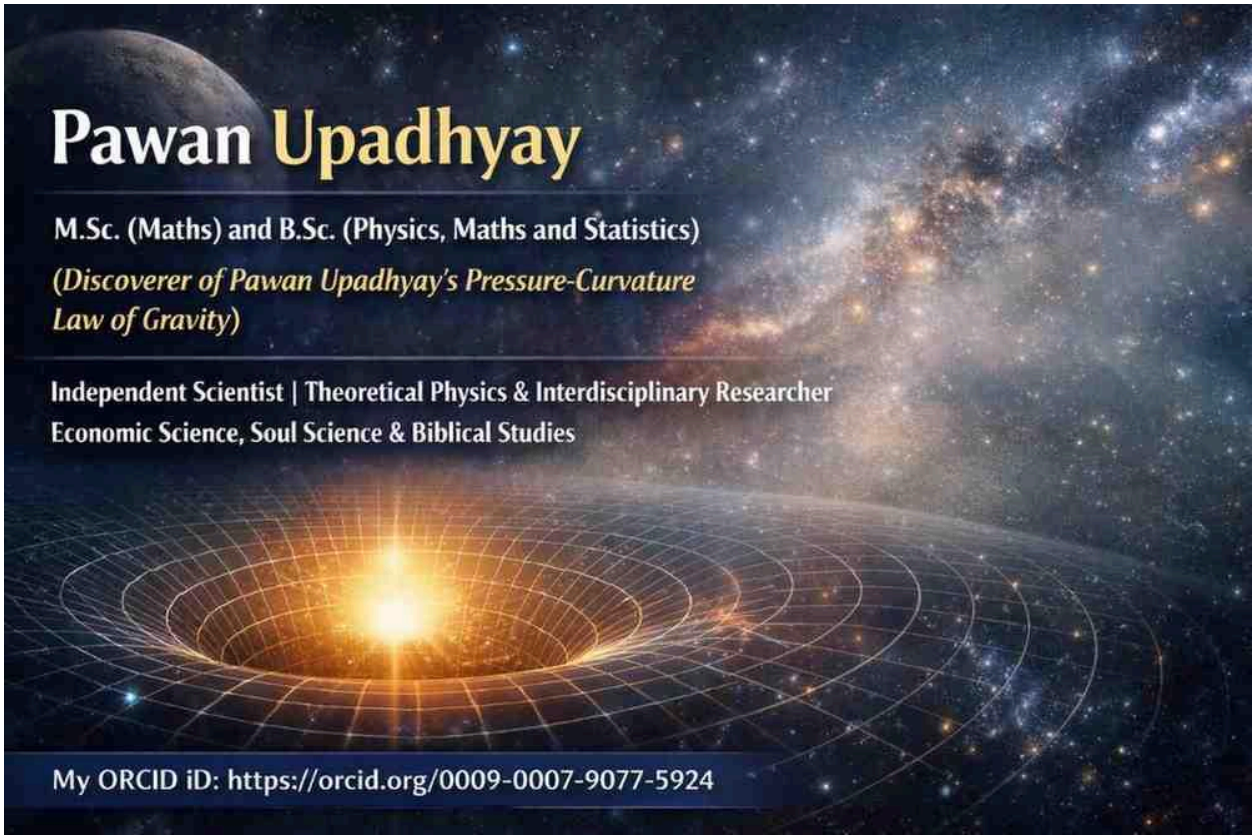
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Abstract

This paper investigates the stability of wormhole structures within the framework of the Pressure–Curvature (PPC) Law of Gravity. Unlike conventional approaches that emphasize energy density as the primary source of spacetime curvature, the PPC framework identifies pressure as a fundamental driver of gravitational effects. Using the relation $P_g=\omega E_d$, we analyze wormhole behavior in high energy density environments such as near black holes. It is shown that when pressure P_g approaches energy density (E_d), curvature becomes strongly compressive, leading to inevitable wormhole throat collapse. The work further examines

whether such collapse is permanent or dynamically reversible and incorporates quantum effects such as Hawking Radiation as a mechanism for evolving pressure–energy conditions. A dynamic model of wormhole stability is proposed, governed by the evolution of the equation of state parameter.

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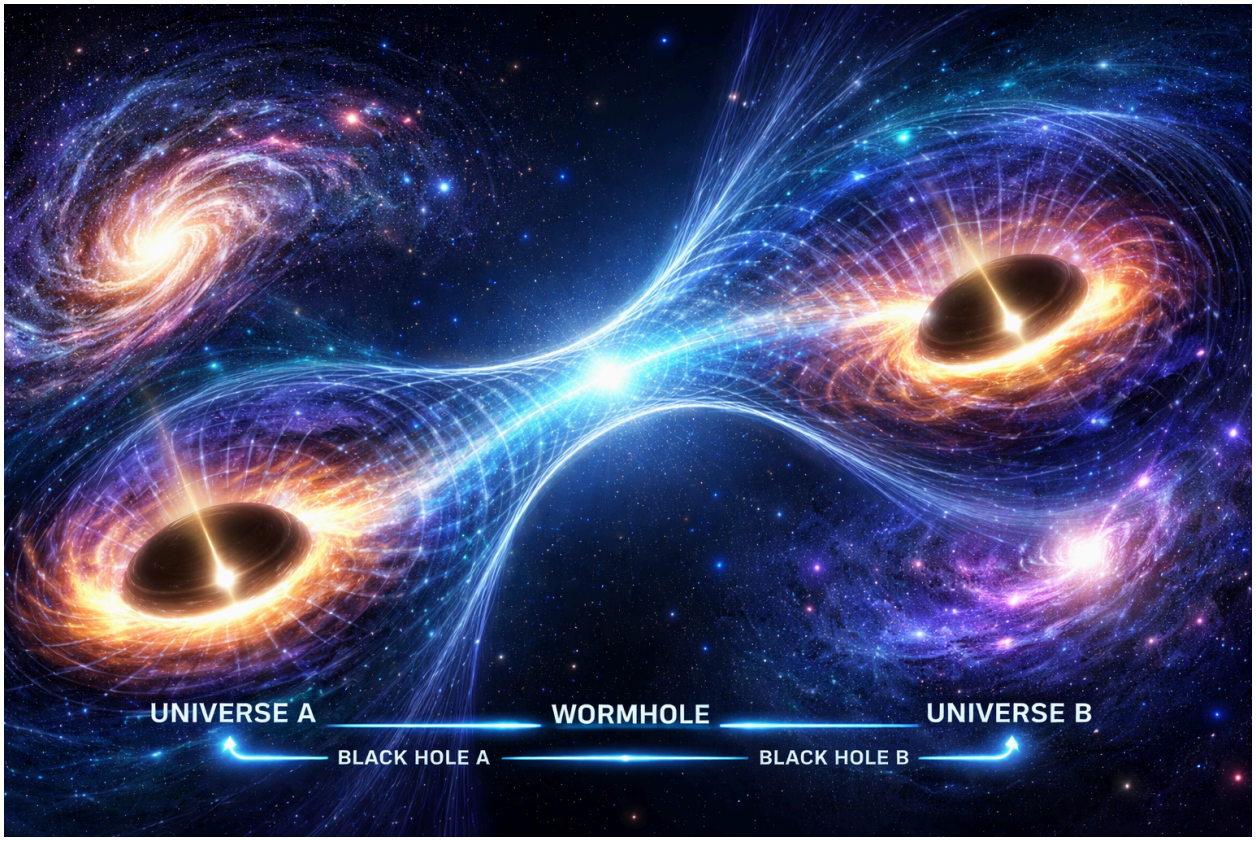
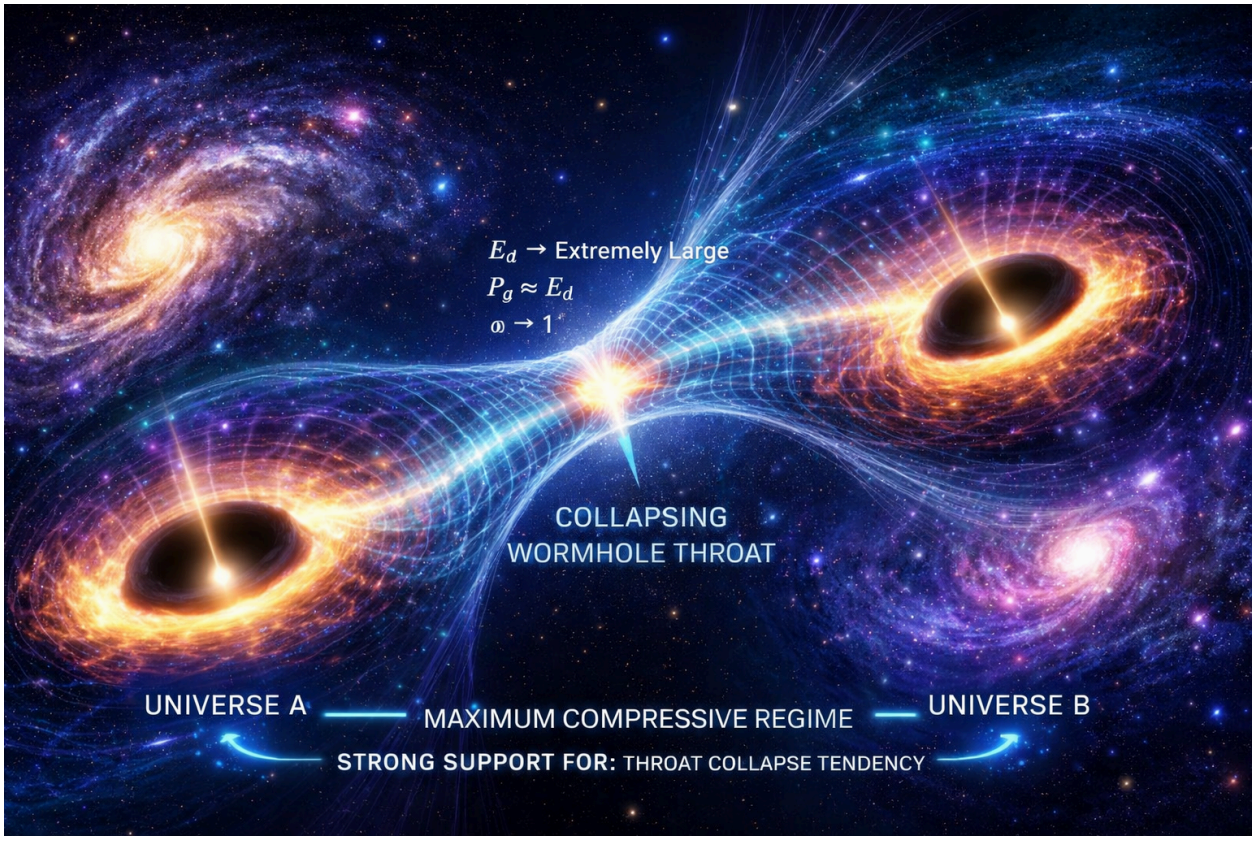
1. Introduction

Wormholes are theoretical spacetime structures predicted by General Relativity, representing non-trivial connections between distant regions. Despite their mathematical validity, their physical existence remains uncertain due to inherent instability.

Standard gravitational theory attributes curvature to the energy–momentum tensor, where pressure appears as one component among others. In contrast, the Pressure–Curvature (PPC) Law of Gravity emphasizes that **pressure itself plays a central and potentially dominant role in shaping spacetime curvature**, especially in extreme regimes.

This work applies the PPC framework to analyze wormhole throat dynamics and demonstrates that **local pressure conditions determine stability**, particularly in high energy density environments.





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2. PPC Law of Gravity

We consider the energy–momentum tensor for a perfect fluid:

$$T_{\mu\nu} = (E_d + P_g)\, u_\mu u_\nu + P_g\, g_{\mu\nu}$$

In the PPC framework:

Pressure is treated as a primary source of spacetime curvature, not merely a secondary contribution.

To characterize physical regimes, we use:

P_g=ωE_d

where:

- E_d : energy density
- P_g : effective gravitational pressure
- ω : equation of state parameter

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3. Physical Regimes Defined by

- **ω = 0** : pressureless matter (dust)
- **ω = ⅓** : radiation
- **ω = 1** : stiff matter (maximum relativistic pressure)
- **ω<0 :** negative pressure (exotic regime)

The value of determines whether curvature is:

- **Compressive (ω≥0)**
- **Repulsive** (**ω<0**)

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4. High Energy Density Regime Near Black Holes

In the vicinity of black holes:

- Energy density becomes extremely large relative to typical astrophysical environments
- Matter behaves in an ultra-relativistic manner

Thus:

$$P_g \approx E_d \quad (\omega \to 1)$$

PPC Interpretation:

Curvature becomes **pressure-dominated and strongly compressive**

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5. Wormhole Geometry and the Throat

A wormhole consists of:

- Two asymptotic regions (mouths)
- A connecting structure known as the **throat**

The throat is:

- The region of **minimum spatial radius**
- The **most unstable component** of the geometry

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6. Pressure-Driven Mechanism of Throat Collapse

Under PPC gravity, when:

$$P_g \approx E_d > 0$$

the following mechanism emerges:

1. Pressure significantly enhances spacetime curvature
2. Curvature acts in a compressive manner
3. The throat radius decreases
4. A geometric pinch-off occurs

Result:

Wormhole throat collapse is a **local pressure-driven instability**

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7. Permanence vs Dynamical Collapse

7.1 Positive Pressure Regime ($\omega \geq 0$)

- Gravity remains attractive
- No known classical mechanism reverses collapse

👉 Collapse is **effectively permanent**

7.2 Negative Pressure Regime (ω<0)

- Curvature becomes repulsive
- Conditions may allow:
    - Stability of the throat
    - Reopening after collapse

Conclusion

Wormhole throat collapse is **conditionally permanent**, governed by the evolution of pressure.

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8. Dynamic Evolution via Hawking Radiation

Hawking Radiation reveals that black holes are not static systems.

“Hawking radiation indicates that black hole systems are not static but undergo continuous energy loss and quantum fluctuations. These processes alter the local energy density and pressure conditions (P_g = ωE_d), potentially destabilizing any associated wormhole throat and leading to its collapse. Thus, Hawking radiation supports the dynamical instability of wormhole structures rather than directly proving their collapse.”

PPC Interpretation:

- Energy density evolves:

$$E_d = E_d(t)$$

$$P_g = \omega E_d (t)$$

👉 Therefore:

Wormhole stability is inherently **time-dependent.**

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9. Single Tunnel Principle

If a wormhole connects two black holes:

- It forms a **single continuous spacetime tunnel**
- Characterized by:
    - One throat
    - Two mouths

However:

- The presence of two black holes does **not guarantee** a wormhole

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10. Final Conclusions

1. In high energy density environments near black holes:

$$P_g \approx E_d$$

2. This leads to:
    - Strong compressive curvature
    - **Wormhole throat collapse**
3. Collapse behavior:
    - Permanent under positive pressure
    - Potentially reversible under negative pressure
4. Hawking radiation introduces:
    - Time-dependent evolution of E_d and P_g .
    - Additional instability
5. Wormholes must be understood as:
    - **Dynamical, pressure-governed structures**

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11. Central Theoretical Statement (PPC Contribution)

Within the Pressure–Curvature (PPC) framework, spacetime geometry is governed primarily by pressure. Wormhole throat stability is determined by the relation P_g = ωE_d. In high energy

$$P_g \approx E_d$$

density regimes such as near black holes, where , pressure-driven curvature becomes strongly compressive, leading to inevitable throat collapse. The persistence or reversal of this collapse depends on the sign and evolution of pressure, establishing wormholes as dynamically governed structures rather than static geometries.